King County
HealthScape
Community design for health and the environment

Evolving the Evaluation of Health and Climate Impacts

A Briefing Paper Prepared by:

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1. Introduction: The Interrelationships Between Climate and Health

In the past several years, planners have become acutely aware of the need to understand how their decisions might impact public health and climate change. In the case of public health, the dramatic increase in rates of obesity and overweight across the country called into question how the communities in which we live may be literally shaping us – and affecting our health in other ways. More recently, the need to curtail carbon emissions from every sector of the economy, especially transportation, has become acute in order to avoid the most disastrous impacts of climate change. Together, these issues have shone a spotlight on the broader relationship between planning, human health, and environmental health – the essence of the HealthScape project.

Research has found that the same general characteristics of the built environment can synergistically advance or undermine public health and climate goals. Research in the first phase of the HealthScape project showed that walkable communities – those that are compact with a mix of land uses and an interconnected street grid – are associated with higher overall rates of physical activity, lower obesity rates, and lower per capita CO2 emissions. This is primarily through the effect of land use patterns on transportation – walkable land use patterns are associated with more transit, bicycling and walking, and less driving; dispersed, single-use neighborhoods dominated by cul-de-sacs are linked to more driving and less 'active transportation' (LFC 2005). A similar study in the Atlanta region showed a link between land use patterns, time spent driving and obesity (Frank et al. 2004). In addition to generating more CO2 and other emissions, more hours in the car also means more sedentary time, and less time available for physical activity. Work in San Francisco (Wier et al 2007) and other places (Dumbaugh 2005) has found narrower streets, slower traffic speeds and lower traffic volumes have benefits to pedestrian safety, and other research in Portland showed a relationship between pedestrian friendly street design and increased walking rates / decreased driving rates (PBQD 1993).

Taken together, the co-benefits of walkable communities is potentially a powerful win – win situation. However, these concepts need to be put in the context of an even broader array of benefits, drawbacks and trade-offs in order to adequately and strategically inform decision-making in specific situations. This means developing tools to evaluate climate and health outcomes alongside or within other more established tools and processes, such as Environmental Impact Assessment (EIA), cost-benefit analysis, or environmental justice analysis. In the case of the public health field, this likely means working in a Health Impact Assessment (HIA) framework. In order to truly articulate the co-benefits discussed above, an integrated approach to Impact Assessment is needed that can comprehensively incorporate both health and climate concerns. The HIA process offers some valuable lessons when looking at climate assessment and impact assessment as a whole.

About this White Paper

The following section of this white paper will introduce the HIA process, discuss how it has been used in decision-making, and talk about how those same strategies and needs can inform climate assessment. Section 3 presents a sample framework for assessing the impacts and benefits of transportation projects that includes health, environmental and climate outcomes. Section 4 discusses an array of metrics, research tools and methodologies that can be used in climate and health impact assessment, and Section 5 discusses several recent US case studies of HIA and climate assessment. Section 6 concludes with several recommendations for building the practice of health and climate impact assessment and incorporating it into planning decisions.

2. An Introduction to Health Impact Assessment (HIA)

Simply put, HIA aims to answer the question: ***is our public policy healthy?*** The simple and common sense notion that decisions should account for their consequences to human health is the fundamental premise of Health Impact Assessment (HIA) (Quigley, 2006). By making health effects, positive and negative, of social decisions more transparent in the policy making process, HIA helps to shape those decisions in ways that improve and protect health for all.

In practice, HIA involves making judgments about the health effects of programs, project, plans, or policies, based upon diverse sources of knowledge, including lay and professional expertise and experience. (Kemm, 2004) HIA also involves stakeholders in the health assessment process and offers recommendations for decision-makers for alternatives or improvements that enhance the positive health impacts and eliminate, reduce, or mitigate negative impacts. In the U.S., HIA is a new and emerging field; however, other countries have successfully used HIA for some time (Bekker, 2007). The World Bank has been supporting the practice of health assessment within environmental assessment since 1986, and many governments provide guidance and resources for conducting HIA. In some countries, rules for regulatory EIA explicitly include guidance for HIA, although that is not the case in the U.S.

The typical steps in an HIA process can parallel the EIA (or EIS, as it is known in Washington State) process and include screening, scoping, assessment, reporting, and monitoring (Quigley, 2006). Appendix A looks at the HIA process in more detail. However, unlike EIA which focuses on biophysical mechanisms, HIA considers social pathways and looks at public decisions that may have social, economic *or* environmental impacts. HIA also extends the focus on adverse impacts found in traditional impact assessment to the evaluation of both costs and benefits, helping to make trade-offs explicit. Furthermore, HIA values research that is qualitative and well as quantitative and includes experiential knowledge. This more holistic viewpoint and respect for qualitative data is an enhancement over traditional EIAs/EISs and could provide a valuable template to follow for climate assessment.

Key HIA Characteristics

Maintains a holistic viewpoint. *Health* includes traditional physical and mental health outcomes like life expectancy, disease rates, and functional status, but it also includes behavioral factors and family, neighborhood, economic, and other environmental factors that influence both health and health behaviors. A broad definition of health is necessary for HIA because most social decisions affect traditional health outcomes indirectly through effects on social and environmental conditions. Climate assessment, which has been largely focused on generating quantitative estimates of greenhouse gas emissions, will need to evolve in order to begin to articulate the far-reaching, dynamic nature of the relationships between climate, health and policy and planning decisions.

Assesses dynamic inter-relationships among physical and social environments (Vanclay, 2002). Environments shape behavior at the individual and societal level. Human behaviors, in turn, shape the environment. Recent research looking at large-scale environmental concerns such as global warming, deforestation, fisheries loss, and suburban sprawl through a lens of human health aims to capture these dynamics. The basic relationship between planning, health and climate can be summarized in the simple figure below:

Planning Decisions → Human Behavior → CO2 Emissions → Climate Change → Human Health

Plurality of Approaches. HIA is not a single tool. Rather, it is a process which employs a range of analytic methods. Within a general framework, approaches to HIA vary greatly with regards to the breadth of issues analyzed, the analytical methods, their relationship to regulatory impact assessment requirements, the role of policy-makers, stakeholders and the public in the analysis, and the ways the assessment is used to influence policy (Cole, 2007).

As with HIA, the process of estimating climate change impacts is complex and involves the dynamic interactions between environmental and social conditions and health at a global scale. Although some tools exist – and more are being developed - to produce quantitative estimates of CO2 emissions, estimating how those changes in CO2 will impact health and the environment is nearly impossible to do with any specificity, given the global scale of the problem and the uncertainty and variability in the data. However, it is possible to qualitatively identify the potential outcome areas, the pathways through which they operate, and whether a given action produces negative or positive impacts.

Benefits of an HIA-Based Approach

Increasing transparency and accountability. Because health is influenced by many diverse social and environmental factors, HIA can provide a comprehensive lens through which to view public policy decisions, making HIA a useful tool to identify strategies that serve multiple aims. Simply informing the process can prevent project delays by anticipating stakeholder concerns, and successfully negotiating these concerns can support a consensus for policy decisions and buy-in for their implementation.

Promoting health and preventing disease in the population. The findings from an HIA can identify and motivate health beneficial changes in a project or policy in the short term. In the longer term, HIA can also increase public and policy-maker understanding of causes of health and disease, creating new strategic opportunities for prevention.

Supporting community engagement. HIA can support community engagement in many ways. First, as a process, it provides a forum for stakeholders to engage in a discussion about a project or plan. Second, as an assessment, it provides evidence that speaks to community questions or positions. Although HIA can play an important role in legitimizing community voices through the consideration and assessment of their concerns, HIA is not intended to be a tool for either pro or anti-development positions. It is critical that HIA practitioners focus on their role to inform, rather than resolve, development debates. By identifying common issues among diverse interest groups, HIA may help to catalyze new relationships and partnerships.

Advancing Equity and Justice. Some policies and decisions may improve the health of one group in the population but negatively affect the health of other subgroups. HIA concerns itself particularly with the distribution of effects on vulnerable populations, or environmental justice. Because the impacts of climate change are also likely to fall on those least able to adapt, there is great value to an approach to climate assessment that examines disparate impacts to different populations.

Supporting root-cause, multi-objective strategies. Most common strategies to address societal problems focus on symptoms instead of on root causes. For example, the principal strategies to address motor vehicle air pollution focus on emissions control and not on the reduction of driving. Root causes are typically more entrenched in culture and there for difficult to change. However, successfully changing a root cause tends to address multiple societal objectives. Adding a health lens to the analysis of a societal problem and its solutions may both create more political will for solving the problem and highlight the value of root cause solutions. For example, reducing vehicle travel,as a strategy to address the root causes of climate change, will have important co-benefits such as increased levels of physical activity and lower traffic injury rates. Politically, a health lens can help create alliances between groups ("smart" growth, environmental, health and environmental justice advocates), creating more possibilities for addressing these root causes.

3. An Example Framework for Impact Assessment of Transportation Systems

A number of well-recognized transportation system health effects are directly proportional to the use of personal motor vehicles:

- Air pollution from automobiles emissions costs the nation 50-70 million days with restricted levels of activity, 20,000 to 46,000 cases of chronic respiratory illness, and 40,000 premature deaths.
- Children living next to busy roadways have more respiratory disease symptoms and lung function measures.
- Vehicle emissions associated with transportation is responsible for a substantial share of greenhouse gas emissions.
- Nationally, for people aged one to 40, traffic injuries are the single greatest cause of disability and death.
- Road traffic noise is a function of vehicle volume, vehicle speed, vehicle type, and road conditions.
- Moderate levels of vehicle associated noise significantly affects sleep, school and work performance, temperament, hearing impairment, and high blood pressure
- Driving takes time away from other health positive activities, such as exercise, community involvement or time with family.

Land use and transportation systems also contribute to climate change. Transportation accounts for a large and growing share of the country's greenhouse gas emissions. Climate change in turn threatens to have global and catastrophic effects on health through the environmental changes it creates - more frequent extreme weather events, flooding, species loss, changes in food production, increases in waterborne and food-borne illnesses, and increases in the vectors of infectious diseases.

Health and environmental impacts of transportation are products of both the structure and operation of transportation systems. Transportation and land use systems structures and transportation operations can have powerful effects on social and individual behavior, which in turn impact health and the environment (see Table 1 below). Comprehensive reviews of transportation—environment—health relationships are available from the WHO and EPA.

Table 1. How the Transportation System Can Effect Social, Environmental and Health Outcomes

Transportation and Land Use System Structures	Transportation System Services and Operations	Social and Environmental Conditions Affected by Transportation Systems	Health Outcomes Affected By Transportation Systems
Roadways Railways Trails and Paths Land use patterns	Motorized Travel Mass Transit Non-motorized travel Level of Service Freight movement Air Travel Rail Travel	Access to Health Resources (Jobs, Schools, Services and Infrastructure) Active Spaces Social Cohesion and Inclusion Environmental Hazards (climate change, air and water pollution; traffic collisions) and Stressors (noise) Residential Integration	Cognitive Development Cognitive Impairment Community Violence Depression Disability Displacement Fractures Hunger Injuries Life expectancy Physiological Stress Physical Activity Respiratory Diseases Subjective Annoyance Sleep Disturbance

Some adverse health impacts of vehicle use can be mitigated through facility design. On average, each 1mph reduction in speed may reduce accident frequency by 5% with effects greatest for urban main roads and low speed residential roads (Taylor, 2000). For example, traffic calming in residential areas can reduce pedestrian accidents on average by 15% (Morrison, 2003). Traffic calming schemes not only reduce injury hazards but have also been demonstrated to increase the perception of neighborhood quality and increase walking.

Transportation and land use patterns can also have beneficial effects to both health and the climate, such as lower per capita CO_2 emissions (LFC 2005), higher levels of physical activity and lower obesity rates (Frank et al 2006), and lower pedestrian injury rates (Weir et al 2007). In turn, it is well established that physical activity can prevent obesity, diabetes, and heart disease, reduce stress, improve mental health, and promote longevity.

Although specific relationships between the different factors vary, the built environment characteristics that produce these beneficial outcomes include:

- Walkable neighborhoods which include compact, mixed land use patterns and high levels of street connectivity (Frank et al 2006; Frank et al 2007).
- Presence of open or recreational spaces (LFC 2005, Troped 2001, Powell 2003), and a high-quality pedestrian realm (PBQD 1993)
- Roadway characteristics such as reduced vehicle volume, narrower roadway widths and slower traffic speeds (Weir et al 2007, Dumbaugh 2005)
- Transit service nearby (LFC 2005)

Transportation projects can also support social networks and enhance community cohesion by improving access and interactions among members within a community. For example, investments in pedestrian facilities or traffic calming not only encourage more short walking and bicycling trips within a community but also provide settings for social interaction. Support, perceived or provided, from neighbors, friends, and family can buffer stressful situations, prevent damaging feelings of isolation, and contribute to a sense of self-esteem and value. The importance of social support to health is profound. In an Alameda County Study those with fewer social contacts had twice the risk of early death, even accounting for other factors including income, race, smoking, obesity, and exercise (Berkman, 1979).

Public transportation in particular provides access to critical health resources, especially for the most vulnerable in society. For many people, including low-income populations who don't own automobiles, accessible, affordable and convenient mass transportation is necessary for most daily activities: to get to work, to take children to school and child care, to shop for groceries and other retail services, and to obtain timely medical care. A study of fifteen low-income neighborhoods in the San Francisco Bay Area found that 66% of residents had no transit access to hospitals and 48% didn't have walking access to a supermarket (Transportation and Land Use Coalition, 2002). Disconnected and lengthy transit routes make the experience of doing daily activities more time intensive, tiring, and stressful. For the elderly and the disabled, limited access to public transit creates barriers to participation in community and civic life, potentially, leading to feelings of depression and alienation (Surface Transportation Policy Project, 2004).

4. Metrics and Research Tools for Impact Assessment of Transportation Projects and Plans

Indicators for Sustainable Transportation Systems

Indicators are measures used to gauge and reflect progress (or failure of progress) towards social goals. (Cobb, 2002). Indicators inspire and focus work, provide evidence and justification for social change, identify, catalyze policy development, and gauge institutional performance. The importance of land use and transportation system indicators to public health is illustrated by the historic use of automobile level of service (LOS). As a well-established measure of roadway capacity in transportation engineering and planning, auto LOS privileges the convenience of motor-vehicle drivers but does not capture the health and environmental impacts of transportation facilities. Actions that improve auto LOS (e.g. increasing roadway or intersection capacity) can increase traffic flow and related adverse environmental and health impacts, including air pollution and pedestrian injuries (Environmental Protection Agency, 2001). Paradoxically, transportation projects that reduce driving, such as transit only lanes and bicycle lanes and sidewalk widening, can worsen measures of auto LOS.

Within the HIA process, indicators serve as metrics to evaluate existing conditions needs and resources for planning as well as to evaluate the proposed project. Some available transportation system performance measures that drive the relationships between transportation, climate and health are listed below. King County currently uses vehicle miles traveled (VMT) and vehicle mode share as key indicators of regional planning objectives.

Vehicle Miles Traveled. VMT is a common measure of transportation demand on freeways and roads and is generally proportional to air pollution, fuel consumption, traffic noise, greenhouse gas emissions, and accident and injury rates. VMT also reflects the amount of time spent represents traveling that might otherwise be spent in productive or leisure activity.

Vehicle Mode Share. Similar to VMT, the share of trips using personal vehicles correlates with pollutant emission, noise, and injuries. Conversely, larger shares of walking or biking trips help people meet recommended minimums of physical activity. Mode share is dependent upon numerous variables, including cost, distance, accessibility, perceived and actual safety, weather, pedestrian safety, traffic and development patterns, availability of bicycle lanes, transit services, and availability of parking.

Pedestrian Quality Metrics. While walking as a mode of travel is strongly dependent on the distance to destinations, the design of the urban environment can also impact whether or not people incorporate walking into their everyday routine. Intersection-level pedestrian quality factors include crossing distance, signal phasing and timing, corner radii, cross walk treatments, and traffic flow. Segment level factors include lateral separation, traffic speeds, and traffic volumes. Other factors important for pedestrian environmental quality include driveway conflicts, turn conflicts, lighting, and shade trees. Some cities have developed pedestrian quality metrics for planning using subsets of above variables. Gainsville, Florida developed quantitative pedestrian LOS measures and standards for the city and tested and evaluated these standards both on existing conditions and proposed projects (Dixon, 1996). Charlotte, North Carolina recently developed a method for pedestrian and bicycle level of service for intersections in 2005 (Charlotte Department of Transportation, 2005). The San Francisco Pedestrian Quality Index includes variables based on empirical research and expert review in five domains: Traffic (e.g. speed limits); Street design (e.g. sidewalk width); Land Use (e.g. restaurants and retail); Intersection Safety (e.g. countdown in signal); and Perceived Safety(e.g. lighting). To use the PQI, staff collects and organizes segment and intersection level data into a GIS from available secondary sources and first-hand observation and measurement. Segments and intersections are assigned a score, based on variable values and assigned variable weights. Street to street variation in scores are illustrated using an aerial map.

Neighborhood Completeness. Neighborhood completeness is concept that aims to reflect a location's accessibility to common retail goods, public services, and neighborhood infrastructure. Neighborhood completeness can be defined as the proportion of residences with a set proximity to a minimum set of services. For example, a city could establish that a complete neighborhood should have nine out of 12 essential public and private services within a ½ mile to all residents, and then estimate the proportion of household residing in such neighborhoods. Neighborhood completeness is a metric used in the LEED-ND (Neighborhood Design) checklist and the Healthy Development Measurement Tool discussed below.

As shown in Tables 2 and 3, indicators of transportation system performance are also related to human health objectives. Harmful impacts such as injuries, air quality and noise increase with greater personal vehicle use. Beneficial human impacts of using transport modes other than vehicles include improved social cohesion and increased physical activity.

Table 2. Relationship between Transportation Indicators and Health / Environmental Outcomes

Indicator	Traffic Injury Rate Reduction	Air Pollution Reduction	CO2 emissions reduction	Noise Reduction	Access to Goods and Services	Physical Activity	Social Equity	Social Cohesion
Vehicle Level of Service (Increase)	-	-	-	-	+ / -	-	+ / -	+ / -
Vehicle Miles Traveled (Reduction)	+	+	+	+	+ / -	+	+ / -	+
Vehicle Mode Share (Reduction)	+	+	+	+	+ / -	+	+	+
Neighborhood Completeness (Increase)	+ / -	+	+	+ /-	+	+	+ / -	+

Table 3. Typical Effects of Common Urban Transportation Projects on Transportation System Indicators

	Auto Level of Service (LOS)	Vehicle Mode Share (VMS)	Vehicle Miles Traveled (VMT) per Household	Pedestrian Environmental Quality	Neighborhood Completeness
Surface light rail or bus rapid transit	Lower	Lower	Lower		
Roadway Widening	Higher	Higher	Higher	Lower	Lower
Pedestrian or Bicycle Facilities	Lower, if loss of vehicle lane	Neutral or Lower	Neutral or Lower	Higher	Higher
Increased Residential Density	Typically lower	Lower	Lower		Higher
Transit Oriented Development	Typically lower	Lower	Lower		Higher
Big box retail	Lower	Higher	Higher	Lower	Lower

Comprehensive Indicator Tools. No single indicator captures all dimensions relevant to an issue; sets of indicators or comprehensive indicator tools may help to provide a more robust picture of health. The Healthy Development Measurement Tool (HDMT) is an example of an evaluation tool that uses multiple indicators to support a systematic assessment of the effects of land use and transportation decision on health.
The HDMT is organized around six elements of a healthy city: Environmental Stewardship, Sustainable and Safe Transportation, Social Cohesion, Public Infrastructure/Access to Goods and Services, Adequate and Healthy Housing, and Healthy Economy. These six elements are further delineated into 27 measurable objectives, and the HDMT includes over 100 community-level health indicators and baseline data for these objectives.

Indicators are divided into two categories: 1) Primary indicators are generally represented by data and are actionable by development and 2) Secondary indicators offer a complementary qualitative assessment of the objective. For almost all indicators, the HDMT also includes development targets for each indicator that, if achieved by a project or plan, are a proxy for indicator improvement. SFDPH along with the Department of City Planning is using the HDMT to evaluate three comprehensive neighborhood plans. Transportation objectives and indicators in the HDMT are summarized below in Table 4. More information about the HDMT and case studies of HDMT applications are available online at: www.TheHDMT.org.

Table 4. Community Health Indicators for Sustainable and Safe Transportation Element of the Healthy Development Measurement Tool

Community Health Objective	Community Healthy Indicator
ST.1 Decrease private motor vehicles trips and miles traveled	ST.1.a Proportion of households with at least one vehicle available ST.1.b Average vehicle miles traveled by San Francisco Residents per day ST.1.c Gross number of vehicle trips per San Francisco resident per day ST.1.d Number of motor vehicle collisions
ST.2 Provide affordable and accessible public transportation options	ST.2.a Proportion of commute trips made by public transit ST.2.b Proportion of households with 1/4 mile access to local bus or rail link ST.2.c Proportion of households within 1/2 mile of regional bus, rail or ferry link ST.2.d Proportion of workers with 1/2 mile access to regional bus, rail or ferry link ST.2.e Proportion of average income spent on transportation expense
ST.3 Create safe, quality environments for walking and biking	ST.3.a Ratio of miles of bike lanes and paths to miles of road ST.3.b Proportion of commute trips made by walking or biking ST.3.c Number and rate of pedestrian injury collisions ST.3.d Number of bicycle collisions ST.3.e Area score on the Pedestrian Environmental Quality Index ST.3.f Proportion of residential streets with 20 mph speed limit

Quantitative Forecasting Tools

Quantitative forecasting of health and climate impacts due to changes in land use and transportation systems generally requires an interdisciplinary approach that bridges methods from transportation, environmental sciences, and public health. For example, forecasting the impact of a new transportation facility on respiratory disease involves estimating the effect of the facility on vehicle flows; the effect of vehicle flows on regional and local air pollutant concentrations; and finally, the effect of that exposure on respiratory disease. Table 5 below identifies several existing tools that may be used in HIA of land use and transportation projects and plans.

Table 5. Quantitative Forecasting Tools Applicable to HIA and Climate Assessment

Purpose or Approach	Description of Tool	Applications to HIA
Impacts of Land Use Design on Vehicle Trips and Travel Distances	Several tools allow users to estimate how land use plans affect transportation impact variables. The approach underlying software packages such as **I-Places3S** and **INDEX** uses a set of empirically tested "elasticities" relating land use parameters, density design, diversity, and destinations, and vehicle trips and vehicle miles traveled. For the HealthScape project, I-PLACE3S is being enhanced to incorporate physical activity and CO2 emissions outcomes based on the results of the research in the first phase of the project (see discussion that follows this table).	
Noise Exposure and Health Risk Assessment	Ambient noise may be measured using available equipment, providing ready measures. Effects of development on ambient noise resulting from changes in vehicle traffic may be predicted using the Federal Highway Administration Traffic Noise Model.	Oak to Ninth Avenue and Mac Arthur BART Development Proposals
Air Pollutant Emissions	**URBEMIS** is an air emission modeling program that also can estimate changes in travel trips resulting from smart growth land use and transportation strategies.	Oak to Ninth Avenue HIA
Air Quality Exposure and Health Risk Assessment	Physical dispersion models provide estimates of ambient air quality resulting from mobile and stationary sources of air pollution. CAL3QHC and CALLINE4 are two examples of dispersion models that estimate pollutant concentrations in the air based on traffic flows, emission factors, and meteorology. Such model can predict diverse pollutants, including carbon monoxide, PM 2.5, PM10, and nitrogen oxides, and have been used in risk assessments used for regulatory standard setting, health evaluation of new air polluting facilities, and several recent land use develop HIAs.	Oak to Ninth Avenue and Mac Arthur BART Development Proposals California Air Resources Board Rail yard and Port Health Risk Assessment
Pedestrian Collision Impact Assessment	Multi-variate models of environmental conditions and accident frequency can be applied to development generated traffic estimates to predict impacts of development using local environmental and pedestrian collision data, the San Francisco Department of Public Health developed area-level multivariate regression model of pedestrian injury collisions that can be used to impacts of growth and development on pedestrian injuries. Variables predicting area level collision frequency included: traffic volume; resident population density; household vehicle access; commute behaviors; street type; and land area. The model has been applied to predict changes in collision frequency resulting land use development plans in San Francisco and will be applied to other transportation policies. Application findings and results are available at www.sfdph.org/phes.	Eastern Neighborhoods Rezoning Plans, SF

Assessing Pedestrian Safety in San Francisco

The San Francisco Department of Public Health recently developed a model to predict how land use development might affect the number of pedestrian injury collisions in San Francisco (Wier, 2007). Using multivariate regression, SFPDH evaluated environmental predictors of pedestrian-vehicle collisions at the census tract scale. The following six variables predicted a significant share of the variation in pedestrian-vehicle counts: Traffic volume; proportion of arterial streets; land area (square miles); car ownership (%, access by housing unit); commuting via walking or public transit (%, pop.); number of residents. We used the forecasting model to analyze the impact of proposals for neighborhood rezoning using estimated changes in resident population and traffic volume provided by the planning department. The plans, by design, were expected to produce both a modest increase in local area traffic volume and a more substantial increase in the resident population. The model predicted that the plans would result in a cumulative 17% increase in 5-year pedestrian injury collision totals or over 30 additional collisions each year (see table). The model also predicted the impact of plans on the city-wide population-based rate of pedestrian injury collisions, increasing from the current rate of 104 to 106 per 100,000 residents. These increases were explained by the high current rates of pedestrian injury collisions in the planning areas and the substantial population increases. Table 6 contains a summary of the results by planning area. The application of the San Francisco Pedestrian Injury Collision Model informed the need for pedestrian safety mitigations in the course of land use planning.

Table 6. Changes in modeled Pedestrian Injury Collision Counts associated with Proposed Eastern Neighborhoods Plans

Planning Area (N, Census Tracts)	Traffic Volume (% increase, CT)	Population (% increase, CT)	Predicted % Change in Pedestrian Injury Collisions
Eastern SOMA (N=5)	15%	25%	20%
Mission (N=13)	15%	8%	14%
Show Place Square/Potrero Hill (N=9)	15%	39%	21%
Central Waterfront (N=3)	15%	58%	24%
All Eastern Neighborhoods (N=23)	15%	16%	17%

Assessing Physical Activity & Climate Change in the I-PLACE3S Model

For the King County HealthScape project, the I-PLACE3S model is being enhanced so it can assess impacts to CO2 emissions and physical activity. The modified I-PLACES model will be calibrated for King County and tested in an Impact Assessment for the 98th Street Corridor in White Center.

The methodology for the model development was piloted in a project for Chino, CA which looked at physical activity and obesity outcomes for three development alternatives in each of three neighborhoods. The Chino analysis was a "one-off" analysis performed outside of a modeling structure. For HealthScape, the research results will be incorporated into the I-PLACES model, allowing for repeated testing, in different areas, by non-technical users.

Several aspects of the I-PLACE^{3}S model makes it an ideal structure for the inclusion of public health and climate change outcomes. I-PLACE^{3}S is a web-based application and is usable at a number of settings and geographic scales. Its modular structure is expandable and flexible. Finally, I-PLACE3S was developed by public agencies; because it is the public domain, this increases its flexibility and broadens its potential utility.

The research results from the first phase of the King County project provide a considerable basis for this work, allowing the evaluation of residential density, retail Floor Area Ratio, street connectivity, and transit accessibility on outcomes such as physical activity, obesity, travel behavior, air pollution and CO_2 emissions. These objective built environment measures will be statistically related with these outcomes and those relationships will be programmed into I-PLACE3S. The model will also allow for adjustment of demographic factors such as age, income and ethnicity.

Once developed for King County, the new version of I-PLACE3S can serve as a pilot and, with additional work, can be used in other urban areas. The land use, transportation and physical activity data that has been collected in King County has also been collected in the Atlanta, San Diego, and Baltimore regions. This allows the development of multi-region relationships that may be more broadly applied in a wide variety of regions in the US and Canada. Appendix B discusses these data sources in more detail.

Qualitative Research

Building an evidence base to conduct HIA requires understanding the day-to-day experiences of people living in neighborhoods and the ways that the physical environment affects their health. This can be accomplished through qualitative research that documents the experiential knowledge of community organizations and residents. A diverse array of qualitative approaches exist for this purpose including focus groups, structured and unstructured interviews, and group consensus processes.

In the case of climate assessment, qualitative discussion is necessary for any discussion of how estimated changes in CO_2 emissions might impact health and environmental conditions. Since climate change is a global phenomenon, although it is possible to restrict the discussion to local impacts, there is not necessarily a relationship between the changes in emissions from a local project and local impacts of climate change. For instance, a project that decreases CO_2 emissions may not decrease local impacts if CO_2 emissions continue to increase in other places around the world.

Zone Analysis

Zone analysis identifies and evaluates existing local areas with high densities of pedestrian injuries (NHTSA, 1998). For example, the *PedSafe* analysis conducted by the San Francisco Metropolitan Transportation Authority in 2003 used the zone analysis approach to identify neighborhoods and intersections that had a high "injury density" (i.e., a large concentration of pedestrian-injury collisions in a relatively small geographic area) (Ragland, 2003). This analysis involved mapping 12,557 reported pedestrian-injury collisions that occurred in the city from January 1990 to May 2001 by severity. The *PedSafe* analysis identified 20 areas of the city, both street segments and geographic areas that had high densities of pedestrian-injury collisions. Injuries were highly concentrated in (i) the greater downtown area and (ii) along major arterials in the rest of the City. *Pedsafe* identified a number of specific neighborhoods or planning areas as having relatively higher densities of pedestrian injuries. For example, Western SOMA contained 5.7% of the City's pedestrian injuries but only 0.93% of the City's area. Injury density appeared to be associated with pedestrian and traffic volumes but not vehicle speeds. Other existing software tools to evaluate traffic safety issues include Pedestrian and Bicycle Crash Analysis Tool and Crossroads. These tools help identify crash patterns and their causes and then link causes to potential mitigation strategies.

5. Health and Climate Impact Assessment in Planning and Environmental Review: Recent Progress

Since 2003, there has been significant formative work to develop and apply HIA methods to land use and transportation planning. The following examples highlight cases where HIA tools have been applied in a way that highlights the connections between policy, transportation systems and human health outcomes.

Integrating Health into Community Planning for San Francisco's Eastern Neighborhoods. In 2002 the San Francisco Planning Department (SF Planning) launched the Eastern Neighborhoods Community Planning Process in order to respond to community demands for comprehensive planning and to address recognized land use conflicts in the Mission, South of Market Area (SoMa), Showplace Square/Potrero Hill, and Bayview/Hunters Point neighborhoods. Many stakeholders in these neighborhoods viewed the planning process, which was primarily focused on the rezoning of historically industrial lands for new residential uses, as not responsive to concerns of unaffordable housing, residential and job displacement, gentrification, public safety, and inadequate open space. In November 2004 the San Francisco Department of Public Health (SFDPH) embarked on an ambitious effort to comprehensively evaluate the health benefits and burdens of the Eastern Neighborhoods plans. SFDPH convened and facilitated a multi-stakeholder Community Council of organizations and public agencies to implement the Eastern Neighborhoods Community Health Impact Assessment (ENCHIA). ENCHIA involved a community council of over 20 diverse organizations and developed a vision of a healthy San Francisco; identified measurable community health planning objectives; produced data and maps to assess how San Francisco was meeting these objectives; and researched urban policy strategies to support health.

In May of 2006, after 18 months of research and deliberation, the ENCHIA process concluded with the creation of San Francisco's *Healthy Development Measurement Tool* (HDMT) described in the previous section. The HDMT was used to evaluate the Eastern Neighborhoods plans as well as other land use development policies, plans, and projects. In parallel with the ENCHIA process, SFDPH also worked with the Department of Planning to improve health analysis within Environmental Impact Reports required by CEQA. The efforts focused more specifically on air quality, noise, and pedestrian safety hazards. Analysis demonstrated significant spatial variation in health outcomes related to these hazards and the potential for significant impacts from new development. The Draft EIR of the Eastern Neighborhoods Rezoning Plans includes new mitigations to protect residents from traffic related air quality impacts and improvement measures for reducing pedestrian hazards (San Francisco Department of Planning, 2007).

Oak to Ninth Avenue Health Impact Assessment. In 2006, in the context of a project-based course on HIA at the UC Berkeley School of Public Health, a team of students and faculty conducted a HIA of a mixed-use development on the Oakland Estuary (UC Berkeley Health Impact Group, 2007). The HIA focused on a discrete set of six issues most relevant to the population health, public debates, and compliance with CEQA. The HIA utilized general scientific literature linking health, economics, and the built environment as well as secondary data analysis of local health demographic and employment statistics to support all such judgments.

The HIA also employed many existing, available quantitative and spatial analytic techniques. For example, the project team used an established air pollutant dispersion model (CAL3QHC) to assess exposure to particulate matter from the vehicles on the adjacent freeway, taking into account, traffic speeds, wind direction and meteorology (USEPA, 2007). The assessment applied published concentration-response functions for air pollutants and health effects to quantitatively forecast significant hazards on mortality and respiratory illness based on expected exposure to vehicle pollutants for future area residents (California Air Resources Board, 1992). To mitigate exposure and protect future residents, the HIA recommended filtering outdoor air using mechanical ventilation systems (Fisk, 2001). The HIA also predicted an increase in 5.4 collisions per year over the area's baseline rate of 100 collisions / year using estimates of project generated vehicle trips and empirical relationships between vehicle volume and collision frequency (Lee, 2005). The HIA included recommendations to the Oakland Planning Commission and City Council for greater social integration, accessibility of open space, prevention of pedestrian injury, mitigation of residential noise and air pollution exposures, reductions in traffic, and provision of educational resources.

Prioritizing Health Needs into the Planning of the Atlanta Beltline. In 2007, the Georgia Tech Center for Quality Growth and Regional Development (CQGRD) reported on a HIA that examined how proposed development along Atlanta's Beltline might affect the health of residents(Center for Quality Growth and Regional Development 2007). The HIA examined the proposal impacts on access to parks and trails, housing, transit and pedestrian safety, and air quality. In general, the HIA predicted the beltline would improve health through improvement in transit services, access to green space and healthy foods and opportunities for physical activity. The study encouraged the City of Atlanta to find ways to fund and implement health promoting elements of the project in a more rapid timeframe. The HIA also advocated for health professionals to be more involved in setting project objectives and the design and evaluation of project elements. Finally, the HIA recommended that development of the beltline prioritize creating and locating affordable housing in a way that ensures that the resources created through the beltline will serve social equity.

The SR 520 Health Impact Assessment. In May 2007, Senate Bill 6099 passed the Washington State Legislature and was signed into law by Governor Gregoire. SB 6099 establishes a mediation process to develop a project impact plan for the SR 520 Replacement Bridge and HOV project. The Keystone Center of Colorado was hired to conduct the mediation process. The legislation includes language directing the mediation team to incorporate recommendations from a health impact assessment (HIA), to be conducted by Puget Sound Clean Air Agency (PSCAA) and Public Health – Seattle & King County (Public Health). The scope for the HIA includes an assessment of climate impacts – its stated goal is to calculate the project's impact on "air quality, carbon emissions and other public health issues."

The HIA will be conducted between August 2007 and December 2008. Public Health and PSCAA have begun the HIA scoping process to determine which health impacts to focus on along with the methods and resources. The HIA work is supported by internal advisory groups in each agency, a national expert from the Centers from Disease Control and Prevention, other health and academic experts along with public involvement. The HIA process will be coordinated with the Mediation Team process to ensure relevant health information is available for decision making throughout their process. The goals of the HIA are:

1. Assess the SR 520 Replacement Bridge and HOV project's impact on "air quality, carbon emissions and other public health issues."
2. Protect the health of the public by raising awareness among decision makers of the relationship between health and the physical, social and economic environment, thereby ensuring that they include a consideration of health consequences in their deliberations.
3. Make recommendations to enhance the positive impacts and to remove or minimize any negative impacts on health.

6. Conclusion: Recommendations for Practice, Research and Policy Development

Ideally health practitioners and land use and transportation planners will recognize the value of a cooperative engagement in land use and transportation planning and be proactive in this engagement. Although the HIA process described in this paper is just one way to assess health and climate impacts, it offers valuable lessons. In reality resource and time constraints, unfamiliarity with disciplinary language, evidence, rules and limited mandates all limit interdisciplinary practice. Ultimately the goal is normalizing an interdisciplinary practice through day-to-day working relationships and open lines of communication. Cooperation need not be formal or mandated, but policy actions can support or require integrated. Policies should recognize and address historic and institutional limits by providing training and resources to public health and planning agencies or require inter-agency cooperation among transportation and planning and their sister public health agencies. Three specific actions that would support HIA and climate assessment in land use and transportation planning include developing guidance for health and climate effects analysis within EIA/EISs; developing interdisciplinary tools for health and climate effects analysis for transportation planning; and supporting inclusive participation in planning.

Guidance for Health and Climate Effects Analysis within EIAs/EISs. Currently, while regulations for NEPA enable health and climate analysis, they provide no guidance on what type of analysis should occur. States or local governments could adopt guidance that facilitates health and climate analysis within EIAs/EISs. Standards could be developed for indicators such as vehicle miles of travel, accessibility of parks, schools, open space and shops and services, transit service,roadway and traffic characteristics,,and land use characteristics. In many cases, these standards could apply to health, environmental, or climate assessment.

Development of Inter-disciplinary Tools. Many existing metrics and analytic tools support health and climate analysis of land use and transportation planning. A robust practice will need additional analytic methods that forecast the effects of changes in human environments. Existing research within transportation and land use planning, environmental science, and environmental health disciplines provides a solid basis for forecasting health impacts and estimating changes in CO2 emissions. Forecasting health impacts due to longer causal pathways will require that practitioners bridge multiple disciplines to develop tools. Such an approach can, for instance, allow planners to predict the effects of transportation system changes on pedestrian-vehicle collisions. A similar approach could potentially link changes in transportation system structures and operations to health-related outcomes such as sleep disturbance, noise related stress, diabetes, respiratory disease, and social cohesion.

Inclusive Participation. Effective and inclusive participation is critical to the success of re-integrating health and land use and transportation planning. Community groups often raise concerns that planning processes ignore day to day social, health and economic impacts of planning decisions. A technical analysis of health effects within planning or environmental review might be responsive to such concerns, but adequate health analysis also requires community participation to identify problems hidden to experts, contribute to more effective solutions, and makes transparent competing values and interests. Meaningful participation requires both recognition of the value of participation and the challenges of participation by agencies responsible for public decisions along with resources that support community capacity for participation. Consensus conferences, habitat conservation planning, and participatory action research (PAR) are all models of more inclusive participation that provide lessons and strategies for impact assessment as well as planning.

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Appendix A. The HIA Process in Practice: Combining a Communication Process and Analytic Methodology

HIA is a process to inform social decisions. Within this process, practitioners use diverse qualitative and quantitative research methods to make judgments about how policies, plans, programs, or projects can affect health, health behaviors, and social resources necessary for health. The typical steps in HIA can include screening, scoping, assessment, reporting, evaluation, and monitoring, as the table below shows.

The Typical Stages in the HIA Process

Stage of HIA	Tasks
Screening *Deciding whether an HIA would be useful, relevent, and timely.*	*Understanding the decision and its alternatives; Identifying potential health pathways and equity effects Identifying available and ongoing analysis; Understanding competing stakeholder positions; Identifying potential for improvements*
Scoping *Deciding which health impacts to evaluate, by what means, and by whom.*	*Developing research questions; Identifying available research methods and data sources; Identifying mitigation strategies*
Assessment *Using data, research, and analysis to determine the magnitude and direction of potential health impacts*	*Document review; Gathering data on existing conditions; conducting Field visits; Secondary data; Mapping; Taking field measurements; applying quantitative forecasting tools; Judging the breadth and magnitude of health effects; Judging the strength of evidence*
Reporting and Communication *Sharing the results and recommendations*	*Writing structured report; preparing letters to decision-makers; comments for the regulatory process; presentations to stakeholders and elected or appointed officials; public testimony*
Evaluation and Monitoring *Tracking how HIA affects the decision and its outcomes*	*Tracking response to comments; media, stakeholder and decision maker statements; decision changes*

HIA is a spectrum of practice. Given that the purpose of HIA is to inform decision-makers **before** they make decisions, an HIA is most often carried out prospectively before the decision is made or the policy is implemented. HIA can often be done quickly and efficiently and optimally will occur early enough in the process to influence design. The time and resources required to complete an HIA depends on the scope of the HIA and the scale of the project. While ample evidence and many qualitative and quantitative tools support making predictions of health impacts, the degree to which issues are analyzed should be appropriate to the scale of the project or plan and the timing of the decision making process. Approaches to HIA vary greatly with regard to the breadth of issues analyzed, the research methods employed, their relationship to regulatory impact assessment requirements, the role of policy-makers, stakeholders and the public in the analysis, and the ways the assessment is used to influence policy. Overall, HIA can be described as a spectrum of practice along several key dimensions described in the table below.

The Spectrum of HIA Practice

	Comprehensiveness	
Focused on single health determinant or health outcome (e.g., particulate matter and asthma)	▯	Considers all potential adverse and beneficial effects on health determinants and outcomes
	Formal Procedures	
Public health official responds to public or decision maker requesting questions on specific impacts	▯	Structured and transparent process that includes screening, scoping, standardized assessment protocols and reporting integrated into regulatory procedures for environmental assessment
	Participation	
Analysis initiated, scoped, and conducted by public health expert	▯	Analysis initiated, scoped, and conducted by community organization

HIA can provide meaningful roles for stakeholder participation. Most commonly, the HIA process has been convened by government agencies affiliated with the public health or environmental health discipline. In other cases, academic institutions or consultants with expertise in health have conducted HIA. An HIA requires technical expertise during the assessment phase, but the process itself can be adapted and conducted by a wide range of people and organizations.

Community organizations can take a leadership role in the organization and conduct of the HIA process. The HIA process would follow the same sequence of steps but the community organization would take the leadership in convening the participants, moving the process forward, and utilizing public health agencies and other expertise as needed to implement the process. Experts could serve a community-led HIA in a range of subordinate roles including facilitation, research, data collection, analysis of impacts, and public testimony.

Options for Community Involvement in HIA

Stage	Community Involvement in HIA organized by experts or public organization
All Stages	▪ Stakeholders and experts convened together to provide oversight to HIA process ▪ Stakeholder and experts review and comment on HIA scope and findings
Screening	▪ *Community stakeholders ask a public or private agency to conduct HIA analysis on a high priority project* ▪ *Interviews with community stakeholders inform the choice of a subject for HIA*

	▪ *(Indirect) Project staff synthesize community testimony from public meetings and hearings or from a concurrent environmental review process*
Scoping	▪ *Community stakeholders participate in a facilitated scoping exercise in dialogue with health experts* ▪ *Community stakeholders participate in a facilitated scoping exercise apart from health experts and project staff merge the scoping questions with those based on expert opinions* ▪ *(Indirect) Project staff synthesize highest priority community issues based on public oral and written testimony*
Appraisal	▪ *Community stakeholders guide project team field visits* ▪ *Staff conducts interviews and focus groups with community members and engaged stakeholders;* ▪ *Community stakeholders interpret or "ground truth" project staff research;* ▪ *Staff and community conduct joint (participatory) research to answer HIA questions; this may include collecting data such as air quality, noise,* ▪ *Staff includes community-led research in the appraisal* ▪ *Something about data analysis*
Reporting and Communication	▪ *Staff presents findings to community residents and stakeholders* ▪ *Staff and community stakeholders jointly interpret and prioritize findings and recommendations* ▪ *Something about strategic planning about to whom, how, and when to release results* ▪ *Community stakeholders report and communicate HIA findings to decision-makers*
Evaluation and Monitoring	▪ *Community stakeholders monitor decision outcomes and long term results* ▪ *Staff solicit community stakeholder experience with HIA process and outcomes*

APPENDIX B. Available Data for I-PLACE3S Model Enhancement

Variable	Region	Study
Land Use • Parcel-based data • Includes measures of intersection density, land use mix, residential density, transit accessibility, and others	Puget Sound (Seattle)	LUTAQH (King Co) / WSDOT (4 county region) (1999)
	Atlanta region	SMARTRAQ (2000)
	King County	NQLS (1999), NQLS Senior/NIK (2006)
	Baltimore region	NQLS (2003), NQLS Senior (2006)
	San Diego	NIK (2006)
Travel data • Vehicle Miles Traveled (VMT) per capita • Vehicle Hours Traveled • Number of trips & distance/time traveled via walking/transit/bicycle/ auto • Percent of trips via walking/transit/bicycle/ auto	Puget Sound (Seattle)	LUTAQH (King Co) / WSDOT (4 county region) (1999, n_people=14000)
	Atlanta region	SMARTRAQ (2001/2002, n_people=18,000)
Physical Activity • Objectively measured (accelerometer) • Adults age 20-65 (* 65 plus, ** 6 to 11, ***16 plus)	King County	NQLS (n_people=1200, 2003/2004), NQLS Senior* (2006/2007, n_people=500), NIK** (2007/2008, n_children=400)
	Baltimore region	NQLS (n_people=900, 2003/2004), NQLS Senior* (2006/2007, n_people=500)
	Atlanta region	SMARTRAQ*** (2001/2002, n_people=350)
	San Diego County	NIK** (2007/2008, n_children=400)
Obesity • Self-report height/weight • Adults age 20-65 (* 65 plus, ** 6 to 11, ***16 plus)	King County	NQLS (n_people=1200, 2003/2004), NQLS Senior* (2006/2007, n_people=500), NIK** (2007/2008, n_children=400)
	Baltimore region	NQLS (n_people=900, 2003/2004), NQLS Senior* (2006/2007, n_people=500)
	Atlanta region	SMARTRAQ*** (2001/2002, n_people=12000)
	San Diego County	NIK** (2007/2008, n_children=400)
CO_2 emissions methodology	Used to develop CO_2 outcomes for King County & Atlanta	Bullitt Foundation
I-PLACE3S "beta" addition of health and climate change modules	King County, WA	HealthScape